Green-Horse Habitat Restoration and Maintenance Project

Climate Change Resource Report

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Introduction

This report analyses the potential effects of the Green-Horse Habitat Restoration and Maintenance Project on climate change. Potential effects from the alternatives were assessed within the context of direct, indirect and cumulative effects to climate change, the effects of climate change on the proposed activities, and information required for findings under the National Environmental Policy Act (NEPA).

Policy, Laws, and Direction

Federal

Clean Air Act of 1963 (Public Law 91-604 [42 U.S. C. 7401-7626])

The Environmental Protection Agency (EPA) issued an 'Endangerment Finding' in 2009 which found that six greenhouse gases (including C02) taken in combination endanger both the public health and the public welfare of current and future generations under the Clean Air Act (CAA) section 202(a) (40 CFR Chapter I).

Draft NEPA Guidance, 2010[1]

In 2010 the Council on Environmental Quality (CEQ) issued draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions. This guidance document was issued by the CEQ for:

"public consideration and comment on the ways in which Federal agencies can improve their consideration of the effects of greenhouse gas (GHG) emissions and climate change in their evaluation of proposals for Federal actions under NEPA. This draft guidance was intended to help explain how agencies of the Federal government should analyze the environmental effects of GHG emissions and climate change when they describe the environmental effects of a proposed agency action in accordance with Section 102 of NEPA and the CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 C.F.R. parts 1500-1508)."

State Context

In 2005, then-Governor Schwarzenegger signed California Executive Order S-3-05, which required an 80 percent reduction in greenhouse gases from 1990 levels by 2050 (State of California 2005).

In 2006, California enacted Assembly Bill 32, The Global Warming Solutions Act, which required a scoping plan for achieving reductions in greenhouse gas emissions by 2020 (California Air Resources Board 2006). The bill's scoping plan contains the main strategies California will use to reduce the greenhouse gases that contribute to climate change. Reducing our emissions by 80

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[1] See DRAFT NEPA GUIDANCE ON CONSIDERATION OF2010 CEQ Draft NEPA guidance on the effects of climate change and greenhouse gas emissions

percent will require California to develop new technologies that dramatically reduce dependence on fossil fuels. This includes achieving a statewide renewable energy mix of 33 percent.

"Carbon Sequestration: The Plan" describes California's role in the West Coast Regional Carbon Sequestration Partnership, a public-private collaboration to characterize regional carbon capture and sequestration opportunities. The plan also acknowledges the role of terrestrial sequestration in forests, rangelands, wetlands and other land resources. The Scoping Plan target for California's forest sector in 2020 is to maintain the current 5 million metric tons of carbon dioxide (CO_2) equivalent of sequestration through sustainable management practices (California Air Resources Board 2008).

In 2009 – the California Natural Resources Agency issued a 'Final Statement of Reasons for Regulatory Action: Amendments to the State CEQA Guidelines Addressing Analysis and Mitigation of Greenhouse Gas Emissions Pursuant to SB97'. This guidance required lead agencies to analyze for the mitigation of greenhouse gas emissions or the effects of greenhouse gas emissions in relation to 'CEQA-required' proposed projects.

Agency Goals and Objectives

US Department of Agriculture Strategic Plan for FY 2010-2015

Goal 2 of the USDA Strategic Plan for FY 2010-2015 (USDA 2010) states: "Ensure our National Forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing our water resources."

- **Objective 2.2 Strategies and Means** (Lead Efforts to Mitigate and Adapt to Climate Change) include incorporating climate change mitigation and adaptation strategies into management practices and using scientific findings for all restoration projects, planning and prescriptions.
- **Objective 2.4 Strategies and Means** (Reduce Risk From Catastrophic Wildfire and Restore Fire to Its Appropriate Place on the Landscape) include safely managing wildland fire and promoting the appropriate use of prescribed fire to restore fire as a natural ecological process on the landscape, improve forest and habitat conditions, and reduce fuel loads and catastrophic fire risk.

Forest Service Strategic Framework for Responding to Climate Change

The Forest Service Strategic Framework for Responding to Climate Change (USDA Forest Service 2008) provides a strategic framework for the Forest Service to guide current and future actions to meet the challenges of climate change. Strategies to address climate change encompass two components:

1. Facilitated Adaptation – which refers to actions to adjust to and reduce the negative impacts of climate change on ecological, economic and social systems, and
2. Mitigation – which refers to actions to reduce emissions and enhance sinks of greenhouse gases so as to decrease inputs to climate warming in the short term and reduce the effects of climate change in the long term.

Forest Service National Roadmap for Responding to Climate Change

The National Roadmap for Responding to Climate Change (USDA Forest Service 2011) was written to respond to the goal of bringing all national forests into compliance with a climate change adaptation and mitigation strategy. The "Roadmap" identifies the Forest Service management response to climate change on the ground as threefold: adaptation, mitigation and sustainable consumption.

Response to climate change will be through adaptive restoration – restoring the functions and processes characteristic of healthy, resilient ecosystems so that they can withstand the stresses and uncertainties associated with climate change. Mitigation strategies include promoting the uptake of atmospheric carbon by forests and indirectly reducing greenhouse gas emissions (USDA Forest Service 2011).

Forest Plan

The Shasta-Trinity National Forests Land and Resource Management Plan (Forest Plan) (USDA Forest Service 1995) does not provide standards and guidelines specific to climate change. It does, however, provide guidance for the following resources that are pertinent to this project.

Forest Plan Goals, Standards and Guidelines

Forest Plan goals related to aspects of climate change that are pertinent to this project include the following:

Air Quality – "Maintain air quality to meet or exceed applicable standards and guidelines" (Forest Plan, page 4-4).

Fire and Fuels – "Restore fire to its natural role in the ecosystem when establishing the Desired Future Condition of the landscape" (Forest Plan, page 4-4).

Standard and Guideline 4-1.a: Protect air quality while achieving land and resource management goals and objectives… (Forest Plan, page 4-13).

Standard and Guideline 4.8d: Plan and implement fuel treatments emphasizing those treatments that will replicate fire's natural role in the ecosystems (Forest Plan, page 4-18).

Management Area and Management Prescription

Of the seven management prescriptions in the project area (Limited Roaded Motorized Recreation, Roaded Recreation, Wildlife Habitat Management, Late-Successional Reserve, Commercial Wood Products, Riparian Reserve, Special Management Area – RNA), approximately two-thirds of the proposed treatment areas are located within two prescriptions: Limited Roaded Motorized Recreation and Roaded Recreation.[2]

There is no management direction for the above management areas specific to climate change.

[2] The Riparian Reserves management prescription occurs within the other management prescriptions.

Other Guidance or Recommendations

Watershed Analysis

The Green-Horse project area falls within the boundaries of the Pit Arm Shasta Lake Watershed Analysis (USDA Forest Service 2010), the Squaw Creek Watershed Analysis (USDA Forest Service 1999) and the McCloud Arm Watershed Analysis (USDA Forest Service 1998). There is no discussion regarding forest ecosystems and climate change; however, the following, fire-, fuels- and air quality-related issues were addressed, with the following recommendations:

- Apply prescribed burning where appropriate to meet resource objectives in the watershed, including (USDA Forest Service 1998):
    - maintaining forest health,
    - reducing natural fuel accumulations,
    - improving wildlife forage and habitat,
    - reducing risk to life and property by catastrophic wildfire, and
    - reducing risk to resource values by catastrophic wildfire.
- Implement a long range fuel management program focused on critical hazard and risk elements identified in the watershed. The majority of this program would consist of prescribed burning; however, stand thinning and mechanical fuels treatment could be used where topography and access are favorable and where such treatments are consistent with current management direction (USDA Forest Service 1999).
- Continue fuels management as needed to reduce fire effects and fire behavior in the analysis area, to meet land management objectives and to restore fire processes as compatible with other resource needs. Focus fuels treatments on areas with high resource values that are subject to high hazard and high risk (USDA Forest Service 2010).
- Manage fuels to reduce the potential for adverse impacts to air quality from future wildfires. Maintain air quality to meet or exceed applicable standards and regulations during fuels treatment activities (USDA Forest Service 2010).

Resource Concerns Identified Through Internal and External Scoping

Public scoping did not generate comments or issues directly related to climate change. Internal scoping did not identify particular concerns regarding climate change.

Alternatives

Alternative 1

No prescribed fire or related treatments would be implemented under Alternative 1. This alternative provides a baseline of conditions used to compare the environmental effects of the action alternatives.

Proposed Action – Revised (Alternative 2)

Alternative 2 proposes the following activities:

- Prescribed broadcast burning or underburning would occur on approximately 41,625 acres.
- Hand thinning and pruning of small trees and brush, followed by hand piling and pile burning or underburning, would occur on approximately 88 acres adjacent to private property.
- Hand thinning and pruning of small trees and brush, followed by hand piling and pile burning, would occur on approximately 35 acres surrounding recreation residences at Campbell Creek.
- Hand thinning and pruning of small trees and brush, followed by hand piling and pile burning or underburning, would occur on approximately 83 acres surrounding bald eagle nest sites.
- Approximately 4.61 miles (4 acres) of dozer line would be constructed or reconstructed in order to assist fire managers in safely conducting prescribed fire.

Fuels treatments would occur over a period of approximately 7 to 10 years. The proposed action does not include any commercial timber harvest, new forest system or temporary road construction, existing road reconstruction or project-related road maintenance.

To accomplish the fuels treatments, a project-specific Forest Plan amendment would be needed. Currently, the Forest Plan requires an average of 20 tons per acre of unburned dead/down material[3] for Management Prescription II (Limited Roaded Motorized) (Forest Plan, p. 4-47). Management direction for Management Prescription III (Roaded Recreation) is to provide an average of 10 tons of unburned dead/down material per acre on slopes less than 40 percent and where feasible, the same amount on slopes over 40 percent (Forest Plan, page 4-65 to 4-66).

We propose to amend the Forest Plan to allow retention of an average of 5 to 15 tons of down wood per acre in the areas designated as Management Prescription II (16,602 acres) or III (9,682 acres). This amendment would only be applicable to the Green-Horse project for the duration of the treatments.

Alternative 3 – No Forest Plan Amendment

This alternative was developed in response to comments requesting that we follow Forest Plan standards for dead and downed wood throughout the project area – in essence, that we not implement the Forest Plan amendment proposed in Alternative 2.

A preliminary analysis indicated that, of the 26,284 acres within Management Prescriptions II and III (for which the amendment was proposed), only about 4,712 acres currently meet Forest Plan standards for dead and downed wood. Of those acres, only about six acres would meet Forest Plan standards following treatment. Since it does not meet the purpose and need of the project to treat only these six acres, under Alternative 3 no land within management prescriptions II and III will be treated. In addition, portions of other management prescriptions will not be treated

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[3] Dead/down material includes standing snags and fine organic matter and large woody material (often referred to as “coarse woody debris”).

because they were scattered and isolated from the remainder of the project area and/or too small to warrant treatment.

No dozer line would be constructed under this alternative, and no fuels treatment would occur around known bald eagle nest sites or the Campbell Creek recreation residences. A total of approximately 13,275 acres be treated under this alternative.

Design Features Common to Both Action Alternatives Relevant to Climate Change

While no project design features specific to climate change were developed, design features for air quality and prescribed fire would minimize effects to air quality and, therefore, may indirectly reduce the short-term (i.e. release of CO_2) effects of project activities on climate change.

Air Quality

Implementation of prescribed fire would comply with applicable Federal, State and Shasta County Air Quality Management District (AQMD) air quality laws and regulations concerning overall project emissions with emphasis on prescribed burning coordination, emissions and smoke impacts mitigations.

1. A smoke management plan would be developed in accordance with AQMD direction and submitted to the AQMD prior to implementation of prescribed fire.
2. Prescribed burning during periods of high public use would be avoided or mitigated through smoke management procedures that would minimize impacts to areas of high public use.

Fire / Fuels

A detailed prescribed fire implementation plan (burn plan) would be completed prior to implementation of prescribed fire. The burn plan would include all elements required by Forest Service Manual (FSM) 5140 and the Interagency Prescribed Fire Planning and Implementation Procedures Guide.

Analysis Methodology

Project-level analysis considers two types of climate change effects – the effect of a proposed project on climate change (e.g. production of greenhouse gasses [GHG])and the effect of climate change on a proposed project (e.g. vegetation resilience to temperature and moisture regime changes) (USDA Forest Service 2009).

Analyses and determination of effects with regard to climate change for the Green-Horse project are presented in a qualitative—rather than quantitative—format given the lack of reliable models available to quantify effects at the project, local or regional level.

Information Sources

We reviewed current publications, peer reviewed literature and studies to analyze the effects of the alternatives on climate change and the effects of climate change on the project. While models to predict changes in carbon storage and release exist, the Forest Service does not have an accepted tool for analyzing all greenhouse gas emissions at the local or regional level.

A summary of current and predicted future trends in climate and climate-driven processes for the Shasta-Trinity National Forest and surrounding lands (Butz and Safford 2011) is included in the project record.

Cumulative Effects Analysis

A mainly qualitative cumulative effects analysis is discussed in this report. Qualitative carbon sequestration as indicated by acres treated to reduce fuels and restore fire as an ecosystem component is considered at the project area and state levels. Carbon release is discussed in the context of the cumulative effect of carbon entering the global pool of atmospheric carbon (no containment).

Desired Condition

Forested landscapes capable of adapting to changing conditions will be more likely to store carbon sustainably (USDA Forest Service 2011). Based on the assumption that climate change is an undesirable condition at least partly due to an increase in greenhouse gases in the atmosphere, including carbon dioxide (CO_2) – the desired condition for the project area with regard to climate change is an ecosystem with conditions that encourage the sequestration of carbon.

Affected Environment

Introduction

Ongoing climate change research has concluded that, on a global scale, climate is changing; that the change will accelerate; and that human greenhouse gas emissions – primarily carbon dioxide (CO_2) and methane (CH_4) emissions – are the main source of accelerated climate change (USDA Forest Service 2009, EPA 2010). Climate change models and the predicted effects on different regions around the world show wide variation, with some regions greatly affected while others less affected. Regional trends over the last century are linked to climate change (Butz and Safford 2011).

Regional Trends

Regional trends linked to climate change are related to forest structure, hydrology and forest fires.

Forest Structure

Fire exclusion over the past 100 years has resulted in increased tree densities and a reduction in shade-intolerant species. Widespread increases in tree mortality in old growth forests across the west, including northern California, have been documented, with the mortality attributed to regional climate warming and associated drought stress (Butz and Safford 2011).

Hydrology

Analyses of hydrometeorological data from the lower Klamath Basin show a decrease in the percentage of precipitation falling as snow and accelerated snowpack melt, resulting in earlier peak runoff and lower base flows. Since the 1940s, snow water equivalent (SWE) has decreased while water use has increased (Butz and Safford 2011). Some glaciers, however, on Mt. Shasta have been advancing (i.e. growing) at least until winter 2013-2014 (Roche 2014 personal communication).

Forest Fires

Data on forest fire frequency, size, and total area burned and severity all show strong increases in California over the last two to three decades. Northern California forests have had substantially increased wildfire activity, with most wildfires occurring in years with early springs, and is likely attributable to both climate and land-use effects. Regarding effects, large percentage increases in moisture deficits in northern California forests were strongly associated with advances in the timing of 'spring'[4] (Butz and Safford 2011).

Fire suppression has led to fuel-rich conditions, and most future climate modeling predicts climate conditions that will likely exacerbate these conditions, thus increasing the likelihood of higher severity effects from wildfire. Additionally, Westerling and others (2006) showed that increasing frequencies of large fires (greater than 1000 acres) across the western United States since the 1980s were strongly linked to increasing temperatures and early spring snowmelt.

Rising temperatures, changing precipitation patterns and declining soil moisture trends have shifted the suitable range for many tree species to higher elevations. With higher rainfall to snowfall ratios and higher nighttime minimum temperatures, broadleaf trees (especially oak species) are predicted to become an increasingly important component of conifer-dominated forests. Higher temperatures also correlate with longer summer drought conditions which, in turn, increase drought stress on seedlings and increase wildfire risk. Mitigating increased disturbance from high-severity wildfires, while promoting species diversity, is the likeliest strategy to enhance ecosystem resilience in the face of climate change (Skinner 2007).

Local Trends

A summary of current and probable future trends in climate and climate-driven processes for the Shasta-Trinity National Forest and surrounding lands was completed in 2011 (Butz and Safford 2011). The summary examined weather station data for temperature and precipitation from six weather stations on or adjacent to the forest. The following information on local trends is derived from the summary.[5]

Temperature

The summary contains no weather station data from elevations above 3600 feet mean sea level (msl), but the highest station available (Mt. Shasta) shows no change in mean annual temperature since 1949 (although daily maximum temperatures are slightly higher). The data suggest that

[4] Spring is defined in this context as natural indicators of seasonal changes (e.g. snowmelt, warming temperatures) and not by calendar date.

[5] The Redding Airport and Oak Mountain weather stations are closest to the project area; however, the summary did not address any temperature or precipitation trends based on information from those two stations.

lower elevations on the Shasta-Trinity National Forest have experienced moderate increases in mean annual temperature of 1º centigrade (1.8º Fahrenheit) or less over the last 75 years, while many higher elevations area have actually experienced a slight drop in mean annual temperatures.

Precipitation

Trends in annual precipitation appear to be positive at three of the five weather stations for which data were analyzed in the summary, but only one appears to be statistically significant. One station shows no change, and the pattern at another is based on too few data to allow interpretation. There is very high interannual variability in all five precipitation records, such that the actual annual mean can't be predicted with accuracy. Total annual snowfall records on the forest are too incomplete to allow for analysis. As previously stated, glaciers on Mt. Shasta have been advancing thus they may be some increase in precipitation values in this localized area (Roche 2014 personal communication).

Regional Projections

Temperature

California's climate is expected to become warmer during this century. During the next few decades, average temperatures are projected to rise between 1 and 2.3° Fahrenheit. Toward the end of this century, statewide average temperatures are expected to rise between 3 and 10.5° Fahrenheit, depending on various scenarios based on population growth, economic development and control of heat-trapping emissions (California Climate Change Center 2006). The most common prediction among recent models is temperature warming by 9° Fahrenheit by 2100 (Butz and Safford 2011).

Precipitation

Although predictions differ between models, on average projections show little change in expected total annual precipitation or in seasonal precipitation patterns in California (California Climate Change Center 2006). The most common prediction among recent models is that precipitation will remain similar or be slightly reduced compared to today (Christensen et al. 2007, Butz and Safford 2011). Most models predicted that summers will be drier than they are currently, regardless of levels of annual precipitation (Butz and Safford 2011).

With the projected rise in statewide average temperatures, more precipitation will fall as rain instead of snow, and the snow that does fall will melt earlier, reducing the Sierra Nevada spring snowpack by as much as 70 to 90 percent. If global warming emissions are significantly curbed and temperature increases are kept in the lower warming range, snowpack losses are expected to be only half as large as those expected if temperatures were to rise to the higher warming range. A hotter, drier climate could promote up to 90 percent more wildfires in northern California by the end of the century by drying out and increasing the flammability of forest vegetation (California Climate Change Center 2006).

With climate change, streams in the west may experience reduced annual runoff, and reduced flows are expected to contribute to contraction or loss of wetlands. Water temperatures are expected to increase, as is erosion. Therefore, sediment loads are also expected to increase, which would affect aquatic habitats (Furniss et al. 2010).

Local Projections

While no modeling specific to the Green-Horse project area exists,[6] a downscaling of three climate models for the Rogue River Basin in southwest Oregon and the Klamath River Basin led to a similar projection for northwest California that precipitation my remain roughly similar to historical levels but may shift in seasonality to occur predominantly in mid-winter months. Rising temperatures will increase the percentage of precipitation falling as rain and decrease snowpack considerably, resulting in drier summers. Both wet and dry cycles are likely to last longer and to be more extreme, leading to periods of deeper drought as well as periods of more extensive flooding (Butz and Safford 2011).

In California, conditions suitable for hardwood forests (oaks, tanoak, madrone, etc.) are projected to expand, while those suitable for conifer-dominated forests are projected to contract. Significant declines in evergreen conifer forests have been predicted in inland northwest California, with subsequent replacement by Douglas-fir/tanoak forest, tanoak/madrone/oak forest, and oak woodlands under most future climate change scenarios (Butz and Safford 2011).

Climate Change and Wildfire Severity

Published accounts illustrate the increased intensity of fires over the last 25 years (Miller et al. 2009, Spies et al. 2006). Miller and others (2009) noted a significant relationship between climate and forest fire activity from the early 20th century through 2006 in the Sierra Nevada and southern Cascade Mountains, with an increasing correlation between precipitation and temperature during the fire season. During the temporal span of their study, particularly over the last 25 years, researchers noted a correlation between increased fire severity and increased annual precipitation (Miller et al. 2009). Precipitation accounted for all or most of the variance in the latest period models.

The increase in fire severity was attributed to increased fuel loadings, and was presumed to be due to a combination of fire suppression and augmented vegetation growth due to increases in precipitation. Peak snowmelt is occurring earlier, fire season is lengthening, summer drought is deepening, and forest fuels are possibly at all-time highs (Miller et al. 2009).

Climate Change and Adaptation

Under some predictive scenarios, changes in climate may occur that exceed the capacity of existing forest tree populations to adjust physiologically and developmentally. In addition, climate change may occur at rates that exceed the capacity of forest species to adapt to new conditions or to migrate to more favorable environments. The forest trees living today will probably compose much of the forests of the next century (Anderson 2011).

Long-term adaptation to climate changes would require healthy and productive forests in the short term (Anderson 2008). The susceptibility or resilience of project area vegetation types to fire, as well as their ability to adapt to meet future climate challenges, may be compromised by a lack of diversity. The project was designed in part to increase age class diversity of vegetation in the project area. Adaptive actions to climate change can occur inadvertently, with the reduction of

[6] To date no published climate change or vegetation change modeling has been conducted for the Shasta-Trinity National Forest. Few future-climate modeling efforts have treated areas as restricted as the State of California. The principal limiting factor is the spatial scale of the General Circulation Models that are used to simulate future climate change scenarios (Butz and Safford 2011).

vulnerability to climate change being an unintended consequence of changes in fire management and suppression strategy (Trainor et al. 2009).

Carbon Cycling

Long-term carbon storage is a function of climate and its effects on fuels, ignitions, and fire severity over time and space, as well as the normal processes of tree growth and decomposition. The amount of carbon removed from the atmosphere is controlled by rates of growth, plant respiration and decay (Mader 2007). In mixed conifer forests, where surface fire effects historically dominated (Agee et al. 2005, Hessburg et al. 2007), rebalancing of carbon occurred by constant thinning and consumption of surface and ladder fuels by frequent, low-and mixed-severity fires (where surface fire effects were dominant), and occasional via patches of stand-replacing fire.

According to Restaino and Peterson (2013), sequestration of carbon in forests has the potential to mitigate the effects of climate change by offsetting future emissions of greenhouse gases. However, in dry temperate forests, wildfire is a natural disturbance agent with the potential to release large fluxes of carbon into the atmosphere. Climate-driven increases in wildfire extent and severity are expected to increase the risks of reversal to carbon stores and affect the potential of dry forests to sequester carbon. In the western United States, fuel treatments that successfully reduce surface fuels in dry forests can mitigate the spread and severity of wildfire, while reducing both tree mortality and emissions from wildfire (Restaino and Peterson 2013).

Carbon Cycling and Forest Management

Forest management activities proposed for this project that are related to climate change include application of prescribed fire and related use of equipment.[7]

[7] Although some pre-commercial thinning and pruning are proposed, these treatments are limited in scope and would, therefore, by themselves have limited effects on carbon cycling. The effects associated with use of equipment to accomplish these treatments and the subsequent pile burning or underburning are discussed below.

Emissions from Equipment Usage

Restaino and Peterson (2013) found that emissions of carbon from equipment usage during fuel treatments amount to a small percentage of the total aboveground carbon stock. There is far greater variability and magnitude in treatment-related carbon emissions from prescribed fire.

Emissions from Prescribed Fire

Agreement exists across observed and simulated treatments that prescribed fire constitutes a substantial proportion of treatment emissions (Finkral and Evans 2008, North et al. 2009, Stephens et al. 2009, Sorensen et al. 2011). Prescribed fire is effective at reducing fine surface fuels and horizontal fuel continuity (van Wagtendonk et al. 1996, Graham et al. 2004), but is not reliable for reducing tree density, crown density, or fuel ladders, often used in combination with thinning to achieve management goals (Gorte 2009).

Prescribed fire may consume substantial surface biomass, with smoldering consumption of the organic layer contributing to smoke and affecting soil nutrient cycling (Neary et al. 1999). Prescribed fire can generate fuels by killing understory trees (Agee 2003), and multiple treatments may be necessary to maintain reduced fire hazard over time.

Fuel treatments may effectively reduce disturbance severity with known carbon costs, yet the expected carbon benefits from fuel reduction are realized only when wildfire occurs (Ager et al. 2010, Hurteau and North 2010).

Carbon Loss from Wildfire

In addition to releasing stored carbon to the atmosphere, intense wildfire can remove carbon from surface soils, emit large quantities of other greenhouse gases, result in large amounts of decomposing woody material, and consume large areas of forest as a mechanism for removing atmospheric carbon. Depending on the forest type, the area burned by a stand-replacing fire does not recover its pre-fire carbon stock for decades (Janisch and Harmon 2002).

The potential trade-off to initial net carbon losses associated with fuel reduction treatments is a decreased risk of future high-severity wildfire and its associated release of carbon to the atmosphere (Hurteau et al. 2008). In dry forests, fuel treatments that successfully reduce surface fuels have been shown to mitigate the spread and severity of wildfire (Fulé et al. 2001, Pollett and Omi 2002, Skinner et al. 2004, Peterson et al. 2005, Omi et al. 2006, Safford et al. 2009, Stephens et al. 2009, Prichard et al. 2010). Some recent studies use results from wildfire simulations to suggest that, in addition to reducing fire severity, fuel treatments may reduce emissions from wildfire (Finkral and Evans 2008, Hurteau et al. 2008, Hurteau and North 2009, Stephens et al. 2009, Reinhardt and Holsinger 2010, Sorensen et al. 2011).

However, other studies suggest that fuel treatments are unlikely to benefit carbon storage and may result in a reduction of overall carbon stocks (Mitchell et al. 2009, Ager et al. 2010, Campbell et al. 2011). Few empirical studies examine carbon emissions from study areas actually burned by wildfire (Campbell et al. 2007, Meigs et al. 2009, North and Hurteau 2011), and only one reports wildfire interactions in treated and untreated stands (North and Hurteau 2011).

Restaino and Peterson (2013) synthesized findings from these studies and compared the relative effects of fuel treatments and wildfire on carbon dynamics. They concluded that all studies agree unequivocally that untreated stands release more emissions to the atmosphere during wildfire than treated stands, and that emissions increase as burn severity increases. Tree mortality from wildfire is also consistently reduced by the presence of fuel treatments.

However, they also concluded that fuel treatments have a finite life expectancy, and fire hazard increases over time as fuels accumulate in treated areas. Repetition and maintenance of fuel treatments are necessary in order to effectively maintain reduced fire hazard over time (Peterson et al. 2005, Johnson et al. 2007, 2011) and thus must be included in analyses of long-term carbon storage.

Environmental Consequences

Alternative 1 - No Action

Direct, Indirect and Cumulative Effects

Effects on Carbon Cycling

Implementation of the no action alternative would have no direct effects on carbon cycling, since no activities would occur that would contribute to atmospheric carbon. Indirectly, the continued accumulation of untreated fuels in the project area would increase the risk that future wildfires would be widespread and of high severity (see the project Fire and Fuels Report). Carbon loss from widespread, high-severity fire would contribute to other sources of greenhouse gases at the project area and State levels. For example, the $C0_2$ emissions predicted from no action in the event of a wildfire via FOFEM modeling (see project air quality report) amounted to 26,673 pounds per acre averaged over the ten-year period.

Effects of Climate Change

Forest preservation (i.e., no active management) can avoid CO_2 emissions. Net carbon storage will cease when the forest meets its biophysical equilibrium – when carbon inputs equal carbon outputs. Absent natural disturbance, the carbon stock then essentially becomes a static pool (US Environmental Protection Agency 2005).

Ongoing trends in the project area (e.g., continued accumulation of untreated fuels, fire suppression activities) would continue, with any change in conditions occurring due to natural processes and human-influenced trends from a global context over time, regardless of a no action decision. A landscape with unnaturally high fuel concentrations and in which suppression of fire continues would be less resilient to the predicted increases in wildfire severity as climate change progresses.

Effects Common to Alternatives 2 and 3

Direct and Indirect Effects

Effects on Carbon Cycling

Implementation of the proposed fuel treatments would result in some short-term releases of carbon, both from prescribed fire and from use of helicopters for aerial ignition, use of chainsaws for precommercial thinning and pruning, and use of dozers to construct or reconstruct approximately 4.61 miles of fire line (Alternative 2 only). Short-term emissions of carbon from the proposed prescribed fire activities would occur during 1-3 burn periods per year (each burn period would average 1-2 days) over approximately 6-10 years.

Thinning and pruning would occur intermittently over the life of the project, while dozer fireline construction/reconstruction would likely be accomplished in the first year or two of implementation. Carbon emissions from equipment use associated with those activities would be short-lived and would not recur over the life of the project.

The burning prescription would favor conditions that would promote mostly low- to moderate-severity surface fire, with limited amounts of high-severity fire (see the project fire and fuels report). Air quality design features would minimize harmful emissions during project implementation as well as reduce predicted emissions from future wildfires. Results from FOFEM modeling showed that $C0_2$ emissions predicted from Alternatives 2 or 3 during implementation were estimated at 0.051 ppm and 0.039 ppm, respectively, averaged over a 10-year implementation period In the event of a wildfire occurring after implementation of either action alternative, the overall $C0_2$ emissions were modeled to be reduced from the 26,673 pounds per acre (no action) to 11,609 and 20,408 pounds per acre for Alternatives 2 and 3 respectively(see the project air quality report).

Effects of Climate Change

Although future climate change at the local level is uncertain, implementation of either action alternative would reduce the risk of future high-severity fires (see the project fire and fuels report), thereby improving the resiliency of the project area to drier or seasonally drier conditions. Moving the project area toward historic fire regime conditions would likely enhance the ability of project area ecosystems to adapt to climate change, whether the shift is toward drier or wetter conditions. If the local climate shifts toward wetter conditions, reduction of current fuel levels would not have a detrimental effect.

Cumulative Effects

As noted above, future fire behavior in the project area (as discussed in the project fire and fuels report) is predicted to be much lower than under the no action alternative. Short-term emissions of carbon from the proposed activities would likely be offset in the event of a future wildfire occurring in or adjacent to the project area. These carbon emissions, however, would be expected to emulate emissions from mostly low- to moderate-severity surface fire, which occurred historically in the project area.

At the global scale, either action alternative would not likely have a measureable effect on climate change. Because greenhouse gases from project activities would mix readily into the global pool of greenhouse gases, it is not possible to determine the indirect effects of greenhouse gas emissions from single or multiple sources (e.g., at the project level). In addition, because the Green-Horse project is quite small in the context of global atmospheric CO_2, implementation of either action alternative will have no measureable effect on global climate change (USDA Forest Service 2009). Additionally, available data indicate that 33 million acres of forest in California store over 13 billion tons of carbon in live trees, snags and down wood (Christensen et al. 2007). The 58,349-acre project area represents a small portion (0.17 percent) of forest lands in California; proposed treatments constitute and even smaller portion (41,836 acres or about 0.1 percent under Alternative 2 and 13,275 acres or 0.04 percent under Alternative 3).

The benefits of fuel reduction would likely begin to decline after about 15-20 years, at which time additional prescribed fire treatments may be needed – depending on occurrence of wildfire and other natural disturbance in the project area.[8]

Comparison of effects between Alternatives 2 and 3

Direct Effects

Alternative 3 would treat considerably fewer acres than Alternative 2; the reduced acres of prescribed fire would, therefore, contribute less short-term carbon loss than Alternative 2. Conversely, the benefits of fuel reduction and enhanced landscape resilience would be realized over a smaller area than under Alternative 2; effects associated with climate change in the untreated areas would be similar to those described under Alternative 1 (no action).

[8] Any future treatments beyond those proposed in this EA would be analyzed in a new NEPA document.

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